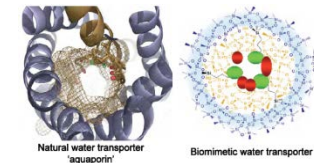
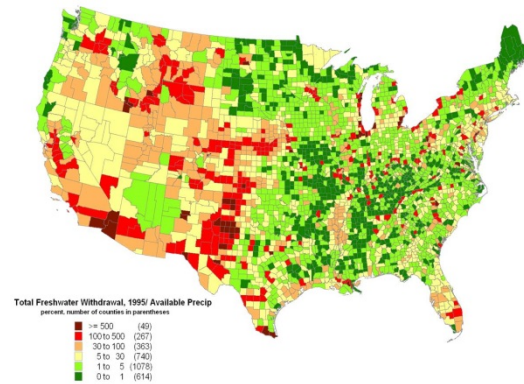


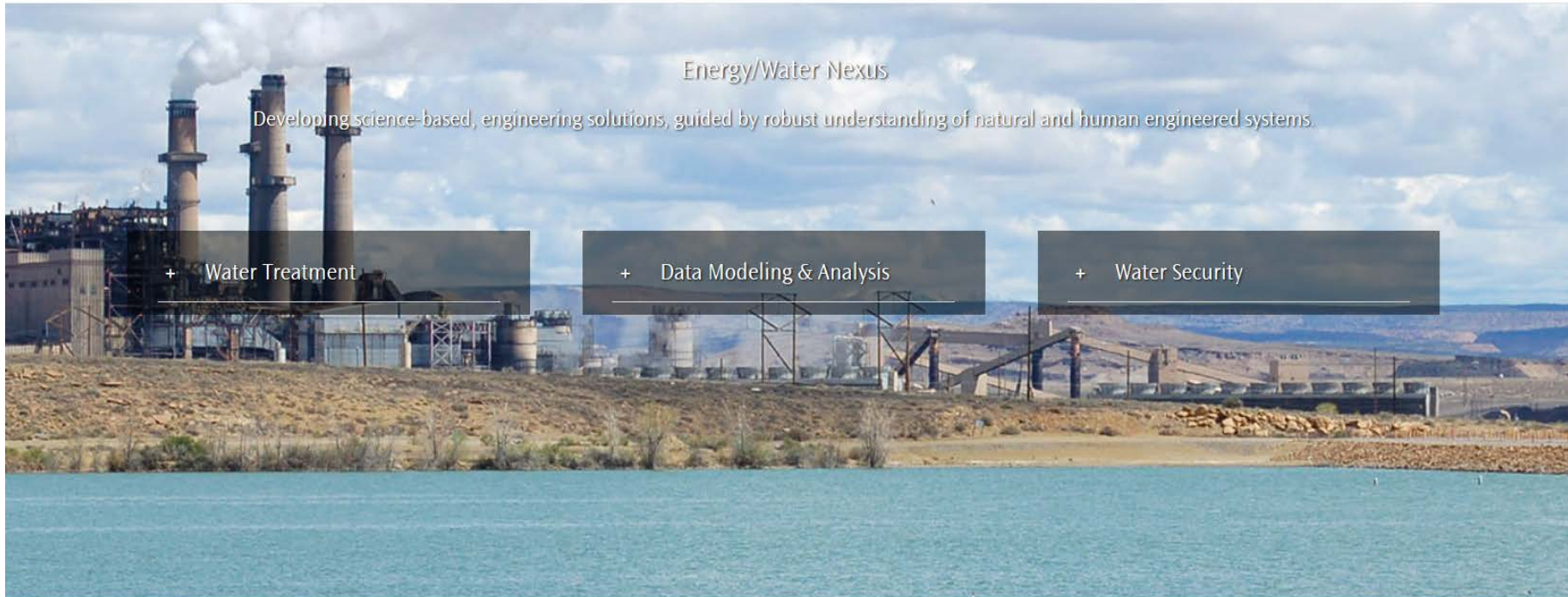
Exceptional service in the national interest



Sandia Water Treatment & Desalination Research, Development & Demonstration

Susan J. Altman, Ph. D.
Manager, Geochemistry Department

March 7, 2017



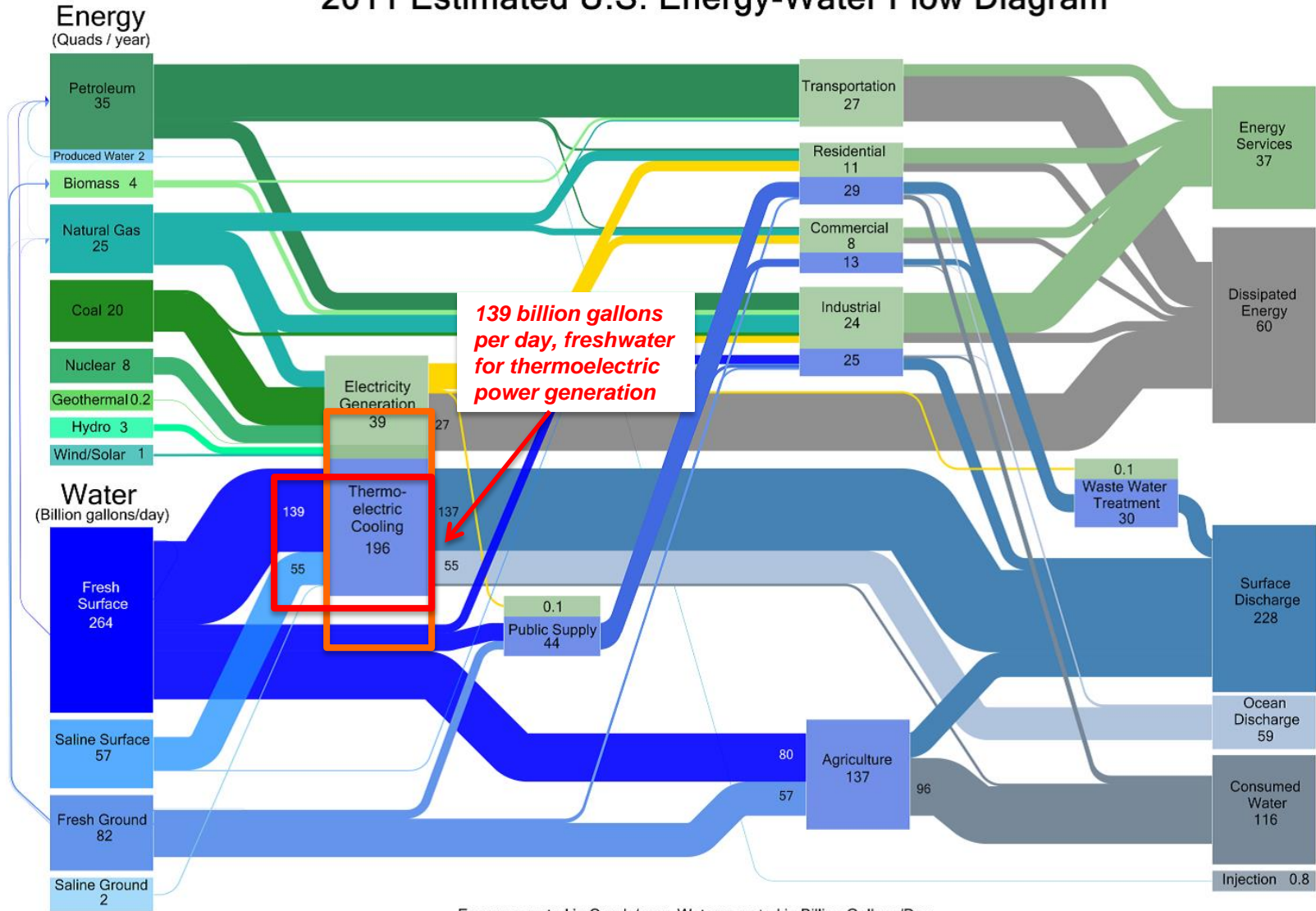
The continued security and economic health of the United States depends on a sustainable supply of both energy and water. The availability of adequate water supplies has a profound impact on the availability of energy, while energy production and power generation activities affect the availability and quality of water. While our supply of water today is largely safe and adequate, we as a nation face increasing water supply challenges in the form of extended droughts, demand growth due to population increase, more stringent health-based regulations, and competing demands from a variety of users.

Sandia's Energy-Water program strives to:

- Increase the safety, security, and sustainability of water infrastructure through the development of advanced technologies that create new water supplies,
- Decrease demand through efficient water use, and
- Provide decision-making tools to the institutions responsible for balancing supply and demand.

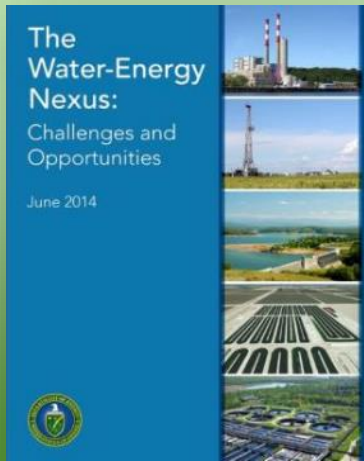
Energy-Water Nexus

2011 Estimated U.S. Energy-Water Flow Diagram

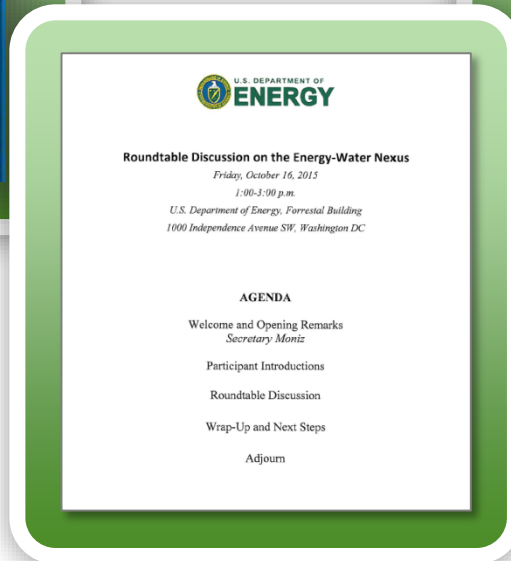


Energy reported in Quads/year. Water reported in Billion Gallons/Day.

Energy-Water Nexus Policy/Budget Developments



June 2014
DOE Water-Energy
Technology Team
Publishes
Water-Energy Report

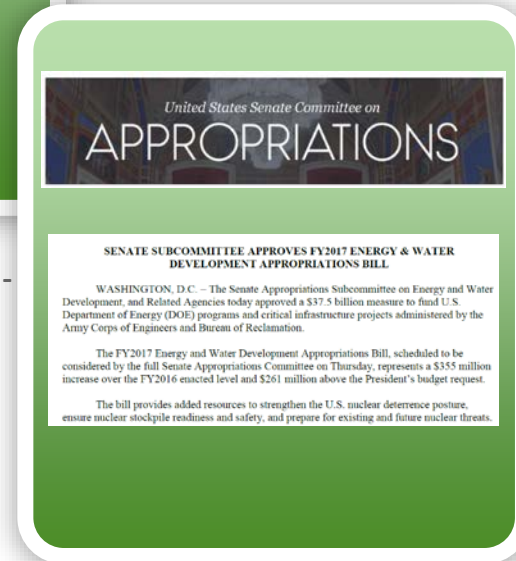


October 2015 Secretary Moniz Hosted
Capstone Energy-Water Roundtable

December 2015 White House Hosted
Energy-Water Event




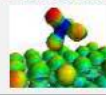




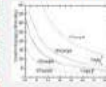

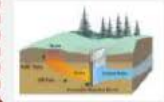
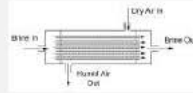


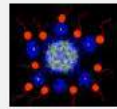


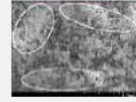


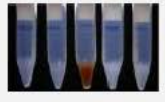





Energy-Water in FY17
President's Budget Request -
\$96M



FY17 Energy & Water Appropriations
(Senate Passed 5/12/16)

Sandia has been actively working in a broad range of water treatment technical challenges for over a decade

<p>ADVANCED CONCEPTS WATER-TREATMENT PROGRAM BEGINS</p> 	<p>DESALINATION TECHNOLOGY ROADMAPS</p> 	<p>ARSENIC WATER TECHNOLOGY PARTNERSHIPS FORMS</p>  <p>DEVELOPMENT OF NOVEL ARSENIC TREATMENT APPROACHES</p> 	<p>JOINT WATER REUSE & DESALINATION TASK FORCE</p>  <p>METHOD FOR SYNTHESIZING LAYERED DOUBLE HYDROXIDE CAPABLE OF SORBING ANIONIC AND IONIC CONTAMINANTS FROM FLUID</p>	<p>COMMERCIALIZATION OF ZERO LIQUID DISCHARGE PROCESS FOR BRACKISH WATER DESALINATION</p>  <p>BRACKISH GROUNDWATER NATIONAL DESALINATION RESEARCH FACILITY</p> 	<p>MEMBRANES & SURFACES NANO-ENGINEERED FOR PATHOGEN CAPTURE & DESTRUCTION</p>  <p>LOW COST ARSENIC TREATMENT SYSTEM FOR SMALL COMMUNITIES</p> 	<p>MICRO-MIXERS FOR MITIGATING MEMBRANE FOULING</p> <p>NOVEL SILICA REMOVAL STRATEGIES BY WARM LIME SOFTENING</p> <p>BIO-FOULING RESISTANT CERAGENIN-MODIFIED WATER TREATMENT MEMBRANES</p> <p>MEMBRANE TREATMENT OF SIDE-STREAM COOLING TOWER FOR REDUCTION OF WATER REUSAGE</p>	<p>PATENT ON METHOD FOR RECOVERING ALKALI METALS</p>  <p>APATITE PERMEABLE REACTIVE BARRIERS FOR IN SITU REMEDIATION OF URANIUM IN SUBSURFACE OF UMTRA SITE</p> 									
<p>2000</p>	<p>2001</p>	<p>2002</p>	<p>2003</p>	<p>2004</p>	<p>2005</p>	<p>2006</p>	<p>2007</p>	<p>2008</p>	<p>2009</p>	<p>2010</p>	<p>2011</p>	<p>2012</p>	<p>2013</p>	<p>2014</p>	<p>2015</p>	<p>2016</p>
 <p>DEVELOPMENT OF SWEEPING GAS MEMBRANE DESALINATION USING COMMERCIAL HYDROPHOBIC HOLLOW FIBER MEMBRANES</p>	 <p>FRONTIERS OF INTERFACIAL WATER RESEARCH WORKSHOP</p>  <p>ARSENIC PILOT DEMONSTRATION PROJECTS</p>	<p>PRODUCED WATER PILOT SAN JUAN BASIN</p> <p>CAPACITIVE IONIZATION FOR COAL-BED NATURAL GAS PRODUCED WATER</p>  <p>PATENT FOR NEXT-GEN COAGULENT FOR THE REMOVAL OF BACTERIA AND VIRUSES</p>	 <p>IMPLEMENTATION OF THE NATIONAL DESALINATION AND WATER PURIFICATION TECHNOLOGY ROADMAP</p>	<p>EXPLOITING INTERFACIAL WATER PROPERTIES FOR DESALINATION & WATER PURIFICATION APPLICATIONS</p> 	<p>SELF-SEALING EVAPORATIVE POND LINER</p>  <p>BIOMIMETIC MEMBRANE R&D 100 AWARD</p> 	 <p>CRYSTALLINE SILICOTITANATES FOR RADIOACTIVE CESIUM REMEDIATION</p>  <p>COAGULATION CHEMISTRIES FOR SILICA REMOVAL FROM COOLING TOWER WATER</p>	<p>WASTE WATER FOR POWER GENERATION VIA ENERGY EFFICIENT SELECTIVE SILICA SEPARATIONS</p>  <p>GRAPHENE OXIDE/POLYMER MEMBRANES</p>  <p>MEMBRANE DISTILLATION PROJECT FOR SMALL NEW MEXICO BUSINESS</p> 									
<p>For more information contact: Susan J. Altman, Ph.D. Geochemistry Department sjaltma@sandia.gov</p>		<p>UV ULTRAVIOLET WATER PURIFICATION SYSTEMS FOR RURAL ENVIRONMENTS AND MOBILE APPLICATIONS</p>														

Sandia has been active

ADVANCED
CONCEPTS WATER-
TREATMENT
PROGRAM BEGINS



DESALINATION
TECHNOLOGY
ROADMAPS



DESALINATION AND WATER PURIFICATION TECHNOLOGY ROADMAP

A REPORT OF THE EXECUTIVE COMMITTEE



Discussion Facilitated by Sandia National Laboratories
and the U.S. Department of Interior, Bureau of Reclamation

Desalination & Water Purification Research & Development Program Report #95

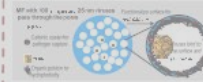


2000 2001 2002 2003

water treatment technical challenges for over a decade

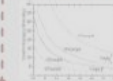
COMMERCIALIZATION
OF ZERO LIQUID
DISCHARGE PROCESS
FOR BRACKISH
WATER
DESALINATION

MEMBRANES &
SURFACES NANO-
ENGINEERED FOR
PATHOGEN CAPTURE &
DESTRUCTION



BRACKISH
GROUNDWATER
NATIONAL
DESALINATION
RESEARCH FACILITY

LOW COST ARSENIC
TREATMENT SYSTEM FOR
SMALL COMMUNITIES



MICRO-MIXERS FOR
MITIGATING
MEMBRANE FOULING

NOVEL SILICA REMOVAL
STRATEGIES BY WARM
LIME SOFTENING

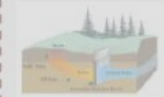
BIO-FOULING RESISTANT
CERAMENIN-MODIFIED
WATER TREATMENT
MEMBRANES

MEMBRANE TREATMENT
OF SIDE-STREAM
COOLING TOWER FOR
REDUCTION OF WATER
REUSAGE

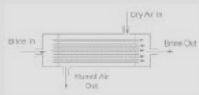
PATENT ON METHOD FOR
RECOVERING ALKALI METALS



APATITE PERMEABLE
REACTIVE BARRIERS FOR
IN SITU REMEDIATION OF
URANIUM IN SUBSURFACE
OF UMTRA SITE



2008 2009 2010 2011 2012 2013 2014 2015 2016



DEVELOPMENT OF
SWEEPING GAS MEMBRANE
DESALINATION USING
COMMERCIAL HYDROPHOBIC
HOLLOW FIBER MEMBRANES



FRONTIERS OF
INTERFACIAL WATER
RESEARCH WORKSHOP

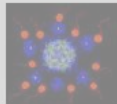


ARSENIC PILOT
DEMONSTRATION
PROJECTS

UV ULTRAVIOLET WATER
PURIFICATION SYSTEMS FOR RURAL
ENVIRONMENTS AND MOBILE
APPLICATIONS

PRODUCED
WATER PILOT
SAN JUAN BASIN

CAPACITIVE
IONIZATION FOR
COAL-BED
NATURAL GAS
PRODUCED
WATER



PATENT FOR
NEXT-GEN
COAGULENT FOR
THE REMOVAL OF
BACTERIA AND
VIRUSES

IMPLEMENTATION
OF THE NATIONAL
DESALINATION
AND WATER
PURIFICATION
TECHNOLOGY
ROADMAP

EXPLOITING
INTERFACIAL
WATER
PROPERTIES FOR
DESALINATION &
WATER
PURIFICATION
APPLICATIONS



MEMBRANE
WATER TREA
POWER PLAN

Implementation of the National
Desalination and Water Purification
Technology Roadmap:
*Structuring and Directing the
Development of Water Supply Solutions*

WASTE WATER FOR
POWER GENERATION
ENERGY EFFICIENT
SELECTIVE SILICA
SEPARATIONS



GRAPHENE
OXIDE/POLYMER
MEMBRANES



PROJECT
NEW MEXICO

For more information contact:

Susan J. Altman, Ph.D.
Geochemistry Department
sjaltma@sandia.gov



is a wholly owned subsidiary of Lockheed Martin
DE-AC04-94AL-8500 SAND2016-12525 M

Efforts to Accelerate Brackish Water Desalination Technology Development

Brackish Groundwater National Desalination Research Facility (BGNDRF) Alamogordo, NM



- Led effort with Bureau of Reclamation on a Report to Congress for the conceptual design of a national brackish water desalination research facility - 2003
- Supported BOR on final design, construction, and operation - 2004 - 2009

Clients:



Broad range of water treatment technical challenges for over a decade



- JOINT WATER REUSE & DESALINATION TASK FORCE
- WATER REUSE
- METHOD FOR SYNTHESIZING LAYERED DOUBLE HYDROXIDE CAPABLE OF SORBING ANIONIC AND IONIC CONTAMINANTS FROM FLUID
- COMMERCIALIZATION OF ZERO LIQUID DISCHARGE PROCESS FOR BRACKISH WATER DESALINATION
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2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010



2016

DEVELOPMENT OF SWEEPING GAS MEMBRANE DESALINATION USING COMMERCIAL HYDROPHOBIC HOLLOW FIBER MEMBRANES

FRONTIERS OF INTERFACIAL WATER RESEARCH WORKSHOP

PRODUCED WATER PILOT SAN JUAN BASIN

CAPACITIVE IONIZATION FOR COAL-BED

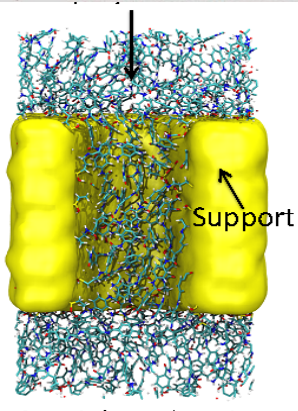
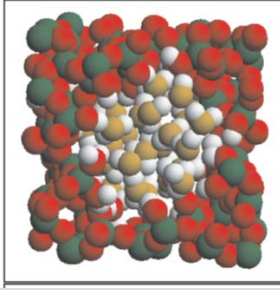
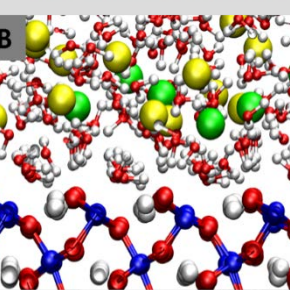
EXPLOITING INTERFACIAL WATER PROPERTIES FOR DESALINATION & WATER PURIFICATION APPLICATIONS

SELF-SEALING EVAPORATION POND

WATER FOR RATION

EFFICIENT SILICA REMOVAL

GRAPHENE POLYMER MEMBRANES



IMPLEMENTATION

NATIONAL

IONIZATION

WATER

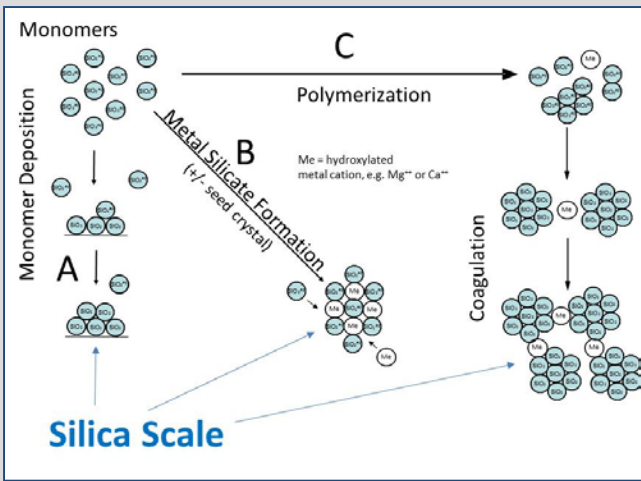
TECHNOLOGY

ADMAP



MEMBRANE DISTILLATION WATER TREATMENT POWER PLANT WASTE





a broad range of

JOINT WATER REUSE & DESALINATION TASK FORCE

WATER SHIPS FORMS

WATER REUSE

METHOD FOR SYNTHESIZING LAYERED DOUBLE HYDROXIDE CAPABLE OF ADSORBING ANIONIC AND IONIC CONTAMINANTS FROM FLUID



challenges for over a decade

- MICRO-MIXERS FOR MITIGATING MEMBRANE FOULING
- NOVEL SILICA REMOVAL STRATEGIES BY WARM LIME SOFTENING
- BIO-FOULING RESISTANT CERAMENIN-MODIFIED WATER TREATMENT MEMBRANES
- MEMBRANE TREATMENT OF SIDE-STREAM COOLING TOWER FOR REDUCTION OF WATER REUSAGE
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2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016

DEVELOPMENT OF SWEEPING GAS MEMBRANE

FRONTIERS OF INTERFACIAL WATER

PRODUCED WATER PILOT SAN JUAN BASIN

CAPACITIVE IONIZATION FOR COAL BED

EXPLOITING INTERFACIAL WATER PROPERTIES FOR DESALINATION & WATER PURIFICATION APPLICATIONS

SELF-SEALING EVAPORATIVE POND LINER

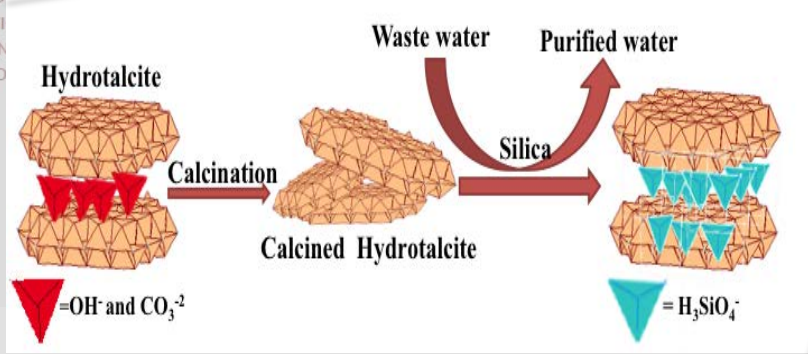
CRYSTALLINE SILICOTITANATES FOR RADIOACTIVE CESIUM REMEDIATION

WASTE WATER FOR POWER GENERATION VIA ENERGY EFFICIENT SELECTIVE SILICA SEPARATIONS

USE OF FLUORINE GAS TO CONTROL SILICA AND CALCITE SCALE IN COOLING TOWERS

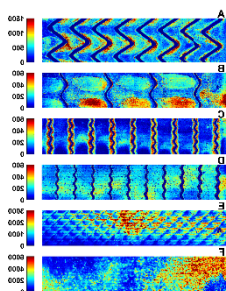
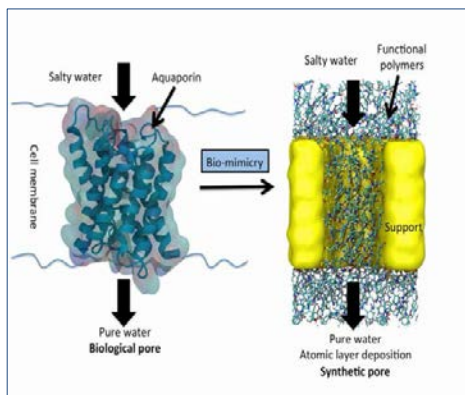
GRAPHENE OXIDE/POLYMER MEMBRANES

Silica: Chloride Ratio	% Silica Removed	Silica: Sulfate Ratio	% Silica Removed
1:1	99.0	1:1	99.0
1:5	98.8	1:5	97.0
1:10	98.5	1:10	95.8
1:15	97.9	1:15	95.2
1:20	97.6	1:20	94.8



Research and Development of Next Generation Water-Treatment Membranes

INTERNAL FUNDING

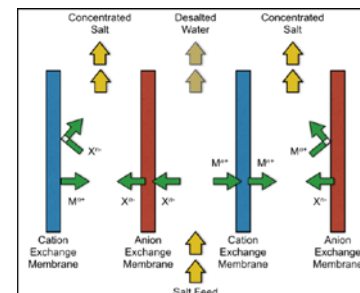
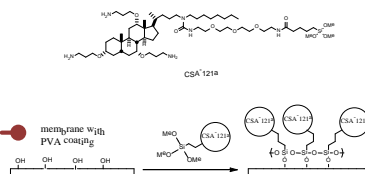


Bio-fouling Resistant Ceragenin-modified Water Treatment Membranes

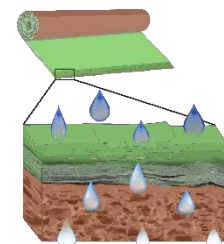
Micro-mixers for Mitigating Membrane Fouling

Fouling

Tunable Biomimetic Membrane for Water Desalination **Nanoporous Membranes**



Bio-inspired Ion-Selective ED Membranes

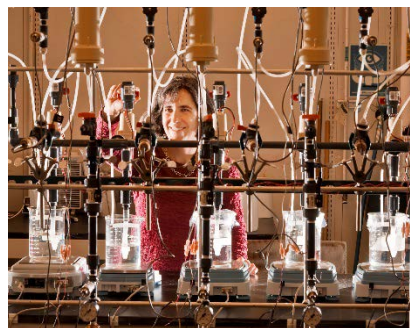


Graphene Oxide/Polymer Membranes

2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016

EXTERNAL FUNDING

DOE Building of Membrane Testing Equipment



EPRI GO/polymer Membrane Treatment of Cooling-Tower Water



Simple Solution to Complex Water Challenge Facing Rural New Mexicans



Installation of high-tech treatment systems which will cost \$58 to \$237 per year for households already experiencing financial strain.



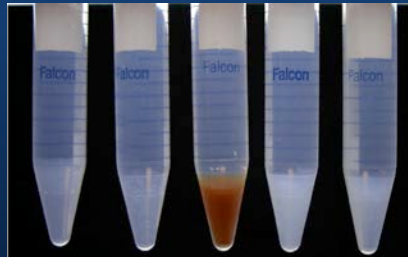
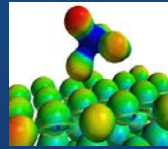
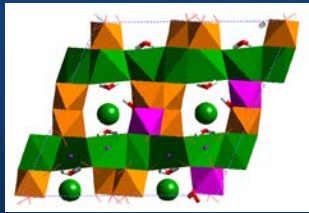
2001: EPA lowers maximum limit for arsenic in drinking water from 50 ppb to 10 ppb. As a result, rural New Mexico communities will be required to deploy costly, sophisticated treatment systems.



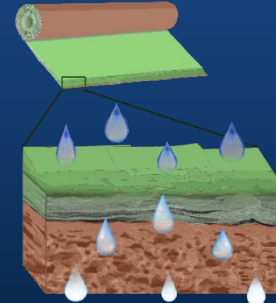
In response to request from NM Senator Pete Domenici, Sandia develops a low-cost solution, known as Hedgehog, that requires no added operation or infrastructure costs and created no added financial burden for rural New Mexicans.

We Manage the Life-Cycle of our Technology

Research



Technology Development



Commercialization



Pilot Programs



Sandia Water Treatment Partnerships: Past and Present



Contact
 Name: Susan Altman
 Phone: (505) 844-2397
 E-mail: sjaltma@sandia.gov

Sandia National Laboratories is a multi-mission laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-ACO4-94AL-8500 SAND2016-XXXX